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ASH CELL GROUND WATER QUALITY - 1987 THUNDER BAY TGS EXTENSION

Report No 88-21-K

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ABSTRACT

Analytical data on ground water samples collected on June 10, 1987 and September 24, 1987, are presented in this report. In general, the relative water levels rose slightly in most locations compared to the 1985 measurements. Levels of some parameters such as sodium, sulphates, boron and/or strontium increased considerably in Boreholes 5B, 15A, 15B, 20A and 20B suggesting possible migration of contaminants from the ash into the ground water system.

job	file	date	report no.
31-151-592	837.71	May 18, 1988	88-21-K

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EXECUTIVE SUMMARY

ASH CELL GROUND WATER QUALITY - 1987 THUNDER BAY TGS EXTENSION

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Analytical data on ground water samples collected from the Thunder Bay Project on June 10, 1987 and September 24, 1987 are reported. These surveys were conducted at the request of Ontario Hydro, Central Thermal Services - Environmental Protection Department. Relative water level measurements taken in 1987 indicated that the water table had increased slightly compared to 1985 levels. Some locations around the ash cell area (piezometers 05B, 15A, 15B, 20A and 20B) showed considerable increases in sodium, sulphates, boron and strontium. This suggests that possible contamination of the ground water by ash leachate is occurring.

job	file	date	report no.
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TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	PIEZOMETER MAINTENANCE	1
3.0	PIEZOMETER AND GROUND WATER LEVEL SURVEYS	1
4.0	GROUND WATER SURVEY - 1987	3
	4.1 pH	3
	4.2 Alkalinity	3
	4.3 Sulphates	4
	4.4 Sodium	4
	4.5 Magnesium	4
	4.6 Boron and Strontium	4
	4.7 Major Ions	4
5.0	SUMMARY AND CONCLUSION	5
6.0	FUTURE WORK	5
7.0	ACKNOWLEDGEMENT	5
REFERENCES		6
APPENDICES		
	A Tables of Ash Cell Ground Water Quality - 1987 Thunder Bay TGS Extension	A1
	B Tables of Ash Cell Ground Water Chemical Analysis - TBTGS - 1987	B1
	C Tables and Graphs of Ash Cell Ground Water Quality TBTGS - 1987	C1
	D Tables of Ash Cell Ground Water Quality - 1987 Thunder Bay TGS Extension	D1
DISTRIBUTION		last page

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To: Mr. M.J. Northfield
Manager
Environmental Protection
Central Thermal Services

ASH CELL GROUND WATER QUALITY - 1987 THUNDER BAY TGS EXTENSION

1.0 INTRODUCTION

Monitoring of ground water quality in the vicinity of the coal ash disposal site (cell No 1), Thunder Bay TGS (TBTGS), began in 1976-1978/1,2/ and continued during 1987. The results of six years of pre-operational monitoring data and five years of post-operational ground water data have previously been reported/1 to 11/.

This report covers the analysis of ground water samples taken from TBTGS on June 10, 1987 and September 24, 1987. Borehole locations are shown on Figure 1 and piezometer reference measurements are included in Appendix A.

2.0 PIEZOMETER MAINTENANCE

Details of piezometer construction and installation in and around TBTGS have been reported previously/1,2,3,9/. For the 1987 sampling period, none of the piezometers were replaced.

3.0 PIEZOMETER AND GROUND WATER LEVEL SURVEYS

Piezometer reference elevations and ground water level measurements were carried out by Civil Research Department and TBTGS personnel. The levels reported are relative to the reference lake level of 182.88 m for the Thunder Bay area. The previous elevation surveys are reported in Appendix A.

The piezometer reference levels (Table A1) indicated that there were no significant changes in piezometer (casing) heights or levels during the 1987 sampling period. The maximum change in piezometer elevation occurred at locations 13A and 13B, where the levels dropped by 5 cm and 6 cm, respectively.

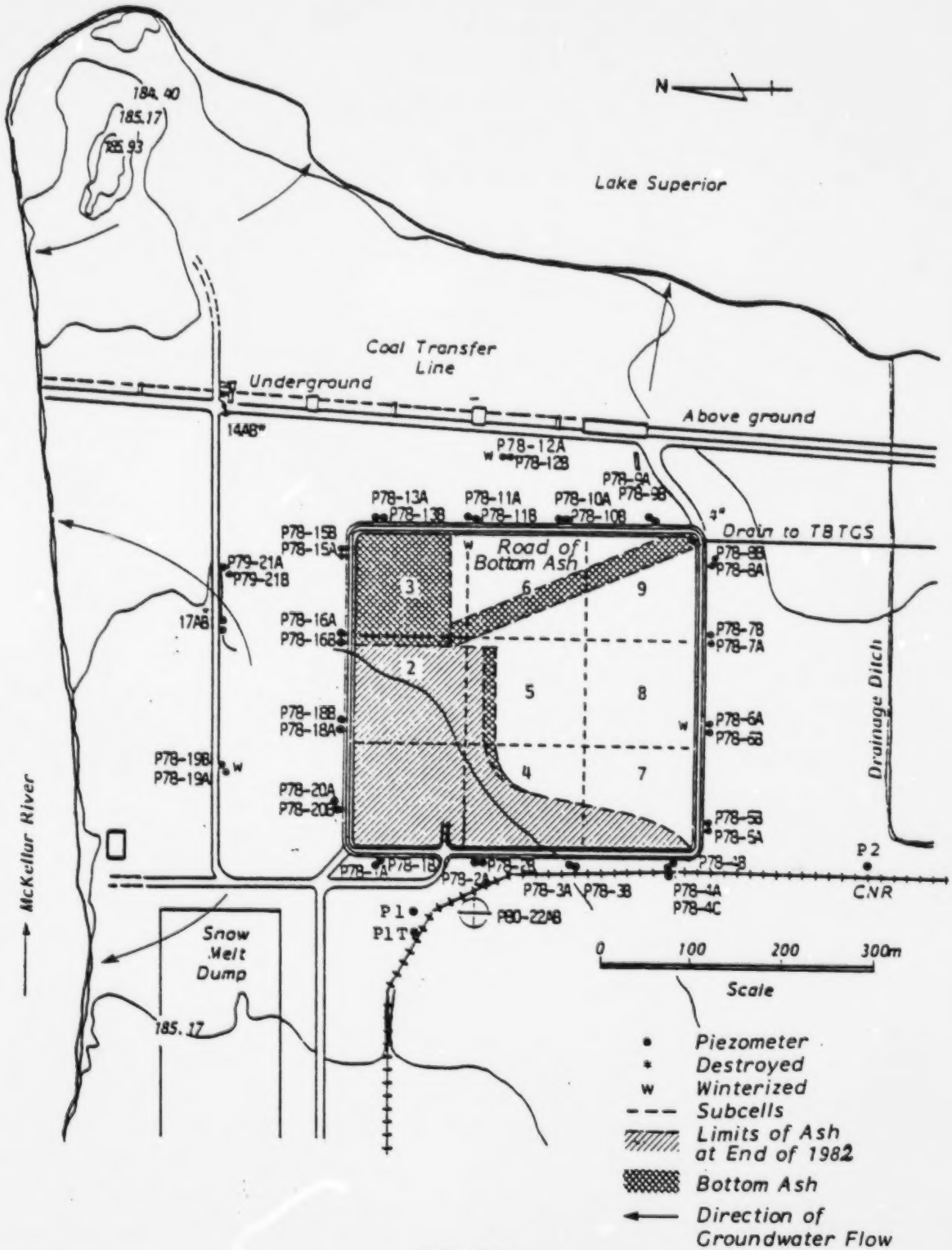

FIGURE 1

ASH DISPOSAL CELL NO. 1
PIEZOMETER NETWORK & LIMIT OF ASH DISPOSAL
THUNDER BAY TGS

157195 RD

88-21

The ground water levels in all the piezometers generally rose in 1987 (Table A2). The most significant increases in the water table occurred at piezometers 1A, 1B, 3A, 3B, 5A, 5B, 8A, 8B, 18A, 18B, 20A and 20B. For most of the above locations, the water levels increased in June and decreased slightly by September, when it was hot and dry and there was little precipitation and ground water recharge. Notable exceptions to the increased water levels were in boreholes 03A, 05A and 08A where the water levels remained the same between June and September.

4.0 GROUND WATER SURVEY - 1987

The methodology used in bailing and sampling has been previously discussed/10/. Detailed chemical analyses of the ground water in and around the site are summarized in Tables B1 to B20 of Appendix B. Field analytical results obtained from TBTGS are also included in the summary. Although the TBTGS (field) data were obtained on the sample samples submitted for comprehensive analysis, the TBTGS data are shown under a different date (one day after the actual sampling date) to differentiate the two data sets.

A comparison of TBTGS (field) data and Research laboratory comprehensive analysis data for selected parameters and locations is shown in Tables C1 to C7 of Appendix C. Time trend analysis for selected parameters and locations are shown in Figures 2 to 8 of Appendix C.

For each sampling location, major ion balances and Piper diagrams were constructed. A summary of the results (major ions and Pipers) are given in Tables D1 and D2 and Figures 9 and 10 of Appendix D.

4.1 pH

Field pH measurements were slightly lower than those measured at Research laboratory. The field pH values ranged from 5.6 (21B) to 6.9 (08B) while those measured in Research laboratory ranged from 5.8 (21B) to 8.0 (18B). The difference between field measured pH and Research laboratory pH is probably due to changes in CO_2 concentrations during sampling, transportation and storage/12/. When excess CO_2 escapes from solution, the bicarbonates are converted to carbonic acid with the corresponding release of hydroxide, which raises the pH. In general, the 1987 field pH values were not significantly different from the 1986 field pH values (Table C1).

4.2 Alkalinity

Most piezometer waters showed alkalinity concentrations >300 mg/L $CaCO_3$, except in locations 21A and 21B (Table C2). In piezometer 21A, the alkalinity levels decreased slightly compared to 1986 levels. For piezometer 21B, the alkalinity levels decreased by more than 50% in the Research Laboratory data while the field data remained essentially unchanged. The significant difference between the field and Research laboratory alkalinity measurement may probably be attributed to CO_2 escaping from the ground water sample and some $CaCO_3$ precipitating out of solution. Other borehole locations such as 01A, 01B, 03B, 12A, 12B, 20A, 20B, 22A and 22B indicated alkalinity levels

> 500 mg/L $CaCo_3$. Piezometers 12A and 12B were sampled in June 1987 only since the site was inaccessible in September 1987. The time trend analysis for alkalinity (Figure 3) indicates that no unusual trends were observed in 1987.

4.3 Sulphates

The waters in the piezometers located around the site exhibited considerable differences in sulphate levels. Major increases in sulphate levels occurred in Boreholes 01A, 01B, 03B, 05A, 08B, 18A and 18B (Table C3, Figure 4). Other locations (03A, 08A, 21B and 22A) showed elevated sulphate concentrations in June while Boreholes 05B, 15B, 20A, 20B and 22B showed considerable increases in September. The high sulphate levels could be due to ash leachate or natural background conditions (swamp) of the area.

4.4 Sodium

The sodium concentrations were relatively stable in most locations except in piezometers 15A and 15B (Table C4, Figure 5). For piezometer 15A, the sodium level rose to 200 mg/L from 42 mg/L reported in September, 1986. Piezometer 15B also had sodium levels of 110 mg/L compared to 59 mg/L reported in September 1986.

4.5 Magnesium

Magnesium concentrations were relatively stable in most waters except in piezometer 01B (Table C5, Figure 6). The level in 01B rose to 94 mg/L from 59 mg/L in 1986. Magnesium concentrations ranged from 5.4 mg/L (21B) to 118 mg/L (15A) in 1987.

4.6 Boron and Strontium

Boron levels measured in 1987, in all the locations, were above the analytical detection limit of 0.05 mg/L (Tables C6 and C7, Figures 7 and 8). Some locations (03A, 05A, 08A, 12A, 12B, 22A) showed relatively stable boron and strontium levels while others (01A, 01B, 05B and 08B) exhibited considerable increases in boron and strontium concentrations. The increased boron and strontium concentrations could be attributed to leachate migrating into the sub-surface waters, since boron and strontium are indicators of fly ash leachate. Elevated levels of boron were also observed in the waters at piezometers 03B, 15A, 15B, 18A, 18B, 20A, 20B, 21A, 22A and 22B while strontium levels remained essentially the same or marginally excessive compared to the 1986 levels.

4.7 Major Ions

Piper plots were drawn to indicate changes in major ion concentrations. For locations 05B, 15A and 15B (Tables D1 and D2, Figure 9 and 10) alkaline earth cations (calcium) and strong acid anions (sulphates) dominate in the waters. All of the other locations are dominated by alkaline earth cations (calcium) and weak acid anions (bicarbonates).

5.0 SUMMARY AND CONCLUSIONS

Thunder Bay TGS ash disposal site was sampled in June and September, 1987. The waters at most of the locations in and around the ash disposal site are characterized as dominant in alkaline earth cations (calcium) and weak acid anions (bicarbonates). However, there appears to be a slight shift to alkaline metal cation (sodium) and strong acid anion (sulphates), particularly in locations 20A and 20B. Other element concentrations, particularly boron, strontium, sodium and sulphates increased considerably at locations 01A, 01B, 05B, 15A, 15B, 20A and 20B compared to the 1986 levels. The increases observed for boron and strontium strongly suggest that ash leachates might be migrating into the ground waters.

6.0 FUTURE WORK

Considering the observed changes in the ground water quality during the 1987 sampling period, it is recommended that the ground water monitoring program continue. Trace metals analyses for elements such as Ag, Al, As, Ba, Cd, Co, Cr^{+6}, Fe, Hg, Mn, Mo, Ni, Pb, Se, SiO_2, Ti, V and Zn should be incorporated into the 1988 sampling program, since these elements could be present in ash leachates.

7.0 ACKNOWLEDGEMENT

The valuable assistance of D.H. Barber and A.Z. Mlynarczyk, in preparation of this report, is highly acknowledged.

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APPENDIX A

ASH CELL GROUND WATER QUALITY - 1987 THUNDER BAY TGS EXTENSION

1. Table A1 - Peizometer Reference Levels 1978 - 1987
2. Table A2 - Relative Water Levels in Piezometers, 1985 and 1987
3. Table A3 - Lake Superior Water Levels, 1987 Station 10050, Thunder Bay

TABLE A1

ASH CELL GROUNDWATER QUALITY STUDIES - 1978-1987
THUNDER BAY TGS EXTENSION

PIEZOMETER REFERENCE LEVELS
1978-1987

Piezometer Identification		Piezometer Reference Levels, m (Above Reference Level of 182.88 m)																		
		Date Surveyed																		
		May 24/78	July 28/78	May 8/79	Nov 2/79	June 5/80	Nov 10/80	July 17/81	Nov 2/81	June 9/82	Nov 3/82	May 18/83	May 18/83	May 15/84	Jun 12/85	June 26/86	June 2/87	Sept 24/87	Δ	Δ'
P78	1A	2.00	2.01	2.13	2.12	2.17	2.19	2.07	2.15	2.17	2.14	2.19	2.19	2.18	2.20	2.20	2.20	2.20	0.00	0.20
	1B	2.12	2.12	2.24	2.24	2.28	2.30	2.19	2.26	2.29	2.26	2.28	2.28	2.28	2.32	2.33	2.32	2.32	0.01	0.20
P78*	2A	2.08	2.08	2.21	2.20	2.24	2.26	2.15	2.21	2.24	2.20	2.22	2.22	2.18	2.23	2.23	-	2.23	0.00	0.15
	2B	2.08	2.09	2.21	2.20	2.25	2.27	2.19	2.22	2.25	2.22	2.23	2.23	2.28	2.25	2.22	-	2.23	0.01	0.15
P78	3A	2.07	2.08	2.20	2.21	2.25	2.29	2.24	2.25	2.28	2.25	2.27	2.27	2.25	2.28	2.28	2.28	2.28	0.00	0.21
	3B	2.05	1.95	2.08	2.09	2.11	2.15	2.12	2.12	2.14	2.11	2.13	2.13	2.11	2.14	2.15	2.14	2.14	0.01	0.09
P78*	4A	2.02	2.04	2.15	2.15	2.19	2.22	2.10	2.17	2.20	2.16	2.18	2.18	2.17	2.18	2.18	-	2.18	0.00	0.18
	4B	1.99	2.00	2.12	2.11	2.16	2.18	2.06	2.14	2.16	2.13	2.14	2.14	2.13	2.15	2.13	-	2.15	0.02	0.16
	4C	1.86	1.87	1.99	1.98	2.03	2.05	1.95	2.02	2.04	2.01	2.02	2.02	2.04	2.09	2.12	-	2.09	-0.03	0.23
P78	5A	1.92	1.93	2.06	2.12	2.19	2.22	2.13	2.22	2.25	2.22	2.28	2.28	2.34	2.40	2.40	2.40	2.40	0.00	0.48
	5B	1.87	1.88	1.99	1.98	2.04	2.08	2.00	2.08	2.12	2.08	2.13	2.13	2.15	2.19	2.19	2.19	2.19	0.00	0.32
P78*	6A	1.79	1.81	1.92	1.91	1.96	1.98	1.95	1.94	1.97	1.93	1.94	1.94	1.94	1.96	1.96	-	1.96	0.00	0.17
	6B	1.80	1.81	1.93	1.91	1.96	1.98	1.93	1.95	1.96	1.92	1.94	1.94	1.94	1.96	1.96	-	1.96	0.00	0.16
P78	7A	1.69	1.71	1.82	1.81	1.87	1.90	1.81	1.89	1.92	1.88	1.86	1.86	1.85	1.94	1.91	-	1.94	0.03	0.25
	7B	1.76	1.78	1.90	1.89	1.94	1.98	1.90	1.98	2.01	1.98	2.00	2.00	2.01	2.10	2.08	-	2.10	0.02	0.34
P78	8A	1.80	1.81	1.93	1.92	2.00	1.99	1.96	1.98	2.02	1.98	1.99	1.99	1.99	2.04	2.03	2.04	2.04	0.01	0.24
	8B	1.80	1.78	1.89	1.88	1.96	1.96	1.93	1.94	1.98	1.95	1.96	1.96	1.95	1.97	1.95	1.97	1.97	0.02	0.17
P78*	9A	1.58	1.59	1.73	1.72	1.78	1.80	1.65	1.78	1.81	1.77	1.80	1.80	1.82	1.85	1.85	-	1.85	0.00	0.27
	9B	1.45	1.45	1.59	1.60	1.66	1.69	1.52	1.66	1.71	1.67	1.69	1.69	1.74	1.77	1.76	-	1.77	0.01	0.32
P78	10A	1.57	1.59	1.71	1.70	1.74	1.76	1.65	1.74	1.80	1.77	1.78	1.78	1.79	1.80	1.80	-	1.80	0.00	0.25
	10B	1.58	1.61	1.73	1.75	1.76	1.80	1.66	1.78	1.83	1.79	1.77	1.77	1.80	1.80	1.79	-	1.80	0.01	0.21
P78*	11A	1.66	1.67	1.80	1.78	1.80	1.84	1.76	1.79	1.82	1.78	1.79	1.79	1.80	1.80	1.81	-	1.80	-0.01	0.14
	11B	1.65	1.67	1.79	1.79	1.80	1.84	1.77	1.80	1.83	1.79	1.80	1.80	1.81	1.80	1.81	-	1.80	-0.01	0.15
P78*	12A	1.61	1.65	1.74	1.76	1.79	1.78	1.81	1.75	1.76	1.75	1.73	1.75	1.77	1.80	1.80	1.80	1.80	0.00	0.19
	12B	1.69	1.70	1.81	1.82	1.87	1.84	1.88	1.84	1.86	1.85	1.86	1.86	1.90	1.92	1.91	1.92	1.92	0.01	0.23
P78	13A	1.81	1.82	1.96	1.94	2.00	2.01	1.91	2.00	2.02	1.99	2.01	2.01	2.03	2.08	2.13	-	2.08	-0.05	0.27
	13B	1.81	1.81	1.94	1.93	1.99	2.01	1.91	2.00	2.05	2.00	2.00	2.00	2.01	2.08	2.14	-	2.08	-0.06	0.47
P78	14A	1.75	1.74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	14B	1.78	1.79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P78	15A	1.93	1.96	2.06	2.05	2.08	2.10	1.94	2.06	2.09	2.06	2.08	2.08	2.08	2.11	2.12	2.11	2.11	-0.01	0.18
	15B	2.21	2.22	2.33	2.34	2.36	2.38	2.23	2.34	2.36	2.34	2.35	2.35	2.35	2.38	2.39	2.38	2.38	-0.01	0.17
P78	16A	1.93	1.96	2.06	2.05	2.08	2.11	2.05	2.08	2.12	2.08	2.11	2.11	2.11	2.19	2.20	-	2.19	-0.01	0.26
	16B	1.98	1.99	2.10	2.13	2.17	2.20	2.13	2.17	2.23	2.18	2.22	2.22	2.27	2.35	2.34	-	2.35	-0.01	0.35
P78*	18A	2.03	2.02	2.14	2.13	2.15	2.18	2.05	2.16	2.20	2.16	2.17	2.17	2.18	2.18	2.18	2.18	2.18	0.00	0.15
	18B	2.18	2.18	2.30	2.31	2.32	2.35	2.23	2.33	2.37	2.33	2.35	2.35	2.36	2.41	2.41	2.41	2.41	0.00	0.23
P78*	19A	2.15	2.15	2.30	2.30	2.32	2.36	2.13	2.30	2.32	2.29	2.34	2.34	2.34	2.38	2.39	-	2.38	-0.01	0.23
	19B	2.15	2.16	2.30	2.29	2.31	2.34	2.11	2.28	2.30	2.28	2.30	2.30	2.30	2.31	2.31	-	2.31	0.00	0.16
P78	20A	2.00	2.00	2.13	2.12	2.16	2.18	2.04	2.16	2.19	2.16	2.19	2.19	2.18	2.22	2.23	2.22	2.22	0.00	0.22
	20B	2.00	2.01	2.11	2.10	2.16	2.18	2.03	2.18	2.24	2.21	2.25	2.25	2.28	2.35	2.35	2.35	2.35	0.00	0.35
P79	21A	-	-	-	1.87	1.90	1.95	1.83	1.99	2.00	1.99	2.02	2.02	2.04	2.06	2.07	2.06	2.06	-0.01	0.19
	21B	-	-	-	1.98	2.01	2.06	1.74	1.90	1.91	1.90	1.96	1.96	1.97	2.00	2.00	2.00	2.00	0.00	0.02
P80*	22A	-	-	-	-	2.15	2.17	2.12	1.98	2.01	-	1.99	1.99	-	-		-	-	-	-
	22B	-	-	-	-	2.01	2.02	1.96	2.14	2.17	-	2.16	2.16	-	-		-	-	-	-

* Winterized wells.
* New wells - installed and elevations measured on June 11, 1980.
Δ Difference from previous level survey, in metres.
Δ' Difference from original 1978, 1979, or 1980 levels, in metres.

(C96)

TABLE A2

ASH CELL GROUNDWATER QUALITY - 1987
THUNDER BAY TGS EXTENSION

RELATIVE PIEZOMETER AND LAKE WATER LEVELS - 1987
(Relative to Average Shoreline Level of 182.88 m)

Piezometer Identification	Relative Water Levels in Piezometers (m)				
	Dates Measurements Taken				
	June 17/85	Aug. 23/85	Sept. 10/85	June 2/87	Sept. 24/87
P78 1A	1.06	0.90	0.84	1.30	1.18
P78 1B	1.15	1.08	1.10	1.32	1.22
P78 2A	1.14	1.12	1.06	-	-
P78 2B	1.15	1.13	1.06	-	-
P78 3A	1.12	1.12	1.07	1.46	1.49
P78 3B	1.12	1.12	1.04	1.41	1.20
P78 4A	1.11	1.12	1.08	-	-
P78 4B	1.10	1.06	1.10	-	-
P78 4C	1.09	1.08	1.03	-	-
P78 5A	1.04	1.07	1.08	1.31	1.32
P78 5B	1.07	1.02	1.04	1.28	1.11
P78 6A	1.06	1.01	1.01	-	-
P78 6B	1.05	1.01	1.01	-	-
P78 7A	1.06	0.99	1.02	-	-
P78 7B	1.07	1.15	1.03	-	-
P78 8A	1.07	1.04	1.04	1.31	1.33
P78 8B	1.08	1.01	1.02	1.31	1.29
P78 9A	0.75	0.80	0.74	-	-
P78 9B	0.74	0.79	0.73	-	-
P78 10A	0.90	0.85	0.88	-	-
P78 10B	0.90	0.82	0.87	-	-
P78 11A	0.90	0.83	0.87	-	-
P78 11B	0.89	0.82	0.85	-	-
P78 12A	0.89	0.80	-	1.17	N/A
P78 12B	0.92	0.96	-	1.17	N/A
P78 13A	0.78	0.87	0.86	-	-
P78 13B	0.90	0.86	0.88	-	-
P78 14A	-	-	-	-	-
P78 14B	-	-	-	-	-
P78 15A	0.95	0.86	0.88	1.11	1.08
P78 15B	0.95	0.91	0.90	1.19	1.13
P78 16A	0.99	0.94	0.96	-	-
P78 16B	1.01	0.97	1.00	-	-
P78 17A	-	-	-	-	-
P78 17B	-	-	-	-	-
P78 18A	1.12	1.00	0.86	1.23	1.20
P78 18B	1.10	1.07	0.96	1.31	1.28
P78 19A	0.89	0.91	0.75	-	-
P78 19B	1.02	0.92	0.67	-	-
P78 20A	1.19	1.11	1.11	1.37	1.32
P78 20B	1.21	1.14	1.13	1.38	1.34
P79 21A	0.91	0.90	0.70	1.18	1.09
P79 21B	0.87	0.91	0.73	1.15	1.12
P80 22A	1.16*	1.42*	1.14*	-	-
P80 22B	1.16*	1.19*	1.12*	-	-
Lake Water** (m)	0.41	0.55	0.60	0.21	0.25

* Based on 1984 reference level.
** Relative Average Monthly Lake Levels (relative to 182.88 m average lake level) for Station 10050, Thunder Bay Harbour. Obtained from Marine Environmental Data, Services Branch, Fisheries and Oceans, Ottawa.

N/A - Not accessible.

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STATION 10050 THUNDER BAY ONT

DAY	MONTH	YEAR	MONTHLY MEANS	DAILY MEANS											HIGH INSTANTANEOUS			LOW INSTANTANEOUS		
															TIME ZONE EST					
															DAY	TIME	HT	DAY	TIME	HT
1	10	1 87		18322	18323	18325	18324	18325	18321	18321	18322	18322	18321							
11	20	1 87		18320	18320	18323	18318	18315	18318	18320	18317	18318	18318							
21	31	1 87	183187	18318	18312	18312	18312	18315	18317	18316	18315	18318	18313	18317	4	1715	18331	27	2215	18308
			(0.307)*																	
1	10	2 87		18316	18314	18313	18314	18314	18314	18312	18308	18313	18312							
11	20	2 87		18314	18308	18313	18309	18310	18312	18311	18311	18310	18311							
21	28	2 87	183112	18311	18310	18309	18309	18310	18311	18309	18307				7	1130	18323	8	445	18295
			(0.232)																	
1	10	3 87		18306	18305	18307	18310	18310	18312	18309	18304	18305	18308							
11	20	3 87		18307	18305	18306	18305	18305	18305	18305	18304	18304	18303							
21	31	3 87	183051	18303	18305	18305	18304	18303	18304	18304	18302	18299	18301	18304	6	2315	18319	28	2130	18293
			(0.171)																	
1	10	4 87		18302	18301	18304	18304	18302	18302	18302	18304	18303	18303							
11	20	4 87		18302	18302	18302	18302	18302	18304	18305	18304	18305	18304							
21	30	4 87	183027	18301	18304	18302	18303	18304	18305	18299	18304	18300	18303		28	1645	18313	27	1015	18286
			(0.147)																	
1	10	5 87		18302	18302	18302	18303	18304	18301	18301	18303	18301	18302							
11	20	5 87		18300	18302	18304	18301	18302	18301	18302	18303	18305	18304							
21	31	5 87	183039	18303	18304	18306	18306	18306	18308	18307	18308	18309	18309	18308	17	200	18320	17	630	18283
			(0.159)																	
1	10	6 87		18308	18311	18309	18310	18309	18309	18309	18307	18309	18310							
11	20	6 87		18311	18310	18310	18309	18309	18308	18310	18310	18308	18308							
21	30	6 87	183086	18308	18309	18309	18309	18308	18307	18307	18308	18306	18306		1	2230	18324	8	215	18297
			(0.206)																	
1	10	7 87		18307	18309	18306	18307	18308	18308	18309	18308	18308	18311							
11	20	7 87		18311	18312	18309	18310	18311	18313	18312	18313	18317	18315							
21	31	7 87	183118	18316	18317	18315	18315	18315	18314	18314	18315	18315	18314	18315	20	1445	18335	11	1400	18295
			(0.238)																	
1	10	8 87		18319	18317	18318	18315	18317	18319	18315	18317	18316	18315							
11	20	8 87		18318	18319	18317	18318	18319	18321	18319	18320	18317	18319							
21	31	8 87	183165	18319	18314	18314	18315	18315	18315	18314	18314	18316	18312	18311	16	1530	18333	30	1945	18305
			(0.285)																	
1	10	9 87		18312	18311	18313	18314	18313	18313	18314	18312	18314	18314							
11	20	9 87		18314	18313	18313	18314	18314	18313	18314	18314	18316	18316							
21	30	9 87	183134	18314	18315	18313	18314	18312	18312	18314	18315	18310	18309		5	2030	18325	5	2145	18299
			(0.254)																	
1	10	10 87		18312	18303	18312	18311	18309	18303	18304	18309	18305	18306							
11	20	10 87		18308	18306	18308	18305	18306	18308	18306	18307	18306	18305							
21	31	10 87	183062	18304	18306	18306	18305	18307	18307	18302	18304	18306	18302	18304	1	1015	18320	2	645	18294
			(0.182)																	
1	10	11 87		18304	18305	18304	18302	18299	18300	18302	18298	18298	18301							
11	20	11 87		18301	18301	18299	18300	18302	18303	18297	18303	18296	18296							
21	30	11 87	183002	18303	18302	18298	18300	18300	18300	18299	18298	18298	18297		2	100	18310	19	1200	18285
			(0.122)																	
1	10	12 87																		
11	20	12 87																		
21	31	12 87																		

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* Values are the difference between the monthly means and the average lake level of 182.88 m

TABLE A3

LAKE SUPERIOR WATER LEVELS - 1989 STATION 10050 THUNDER BAY
(From Marine Environment Data Services Branch, Fisheries and Oceans, Ottawa, Ontario, Canada

APPENDIX B

ASH CELL GROUND WATER CHEMICAL ANALYSIS - TBTGS - 1987

(All values are in mg/L except pH, alkalinity, and conductivity)

- pH in pH units
- conductivity in mS/m
- alkalinity in mg/L $CaCo_3$

Table B1

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 01A

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	552.	680.	555.	740.
ALKOH	<5.00	--	<5.00	--
B	0.290	--	1.01	--
CA	161.	--	190.	--
CL	63.5	--	44.8	--
COND	127.	130.	155.	140.
K	1.84	--	2.00	--
MG	69.0	--	79.0	--
NA	17.0	--	26.0	--
PH	6.70	6.64	7.05	6.54
SO4	118.	--	244.	--
SR	0.270	--	0.350	--

* Field data stored with next day's date.

Table B2

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 01B

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	416.	420.	664.	800.
ALKOH	<5.00	--	<5.00	--
B	0.780	--	2.01	--
CA	89.0	--	180.	--
CL	27.8	--	50.2	--
COND	85.0	70.0	160.	140.
K	3.14	--	2.00	--
MG	44.0	--	94.0	--
NA	21.0	--	34.0	--
PH	7.50	6.95	7.20	6.74
SO4	19.7	--	207.	--
SR	0.190	--	0.320	--

* Field data stored with next day's date.

Table B3

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 03A

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	495.	520.	472.	540.
ALKOH	<5.00	--	<5.00	--
B	0.0900	--	0.100	--
CA	113.	--	109.	--
CL	20.6	--	24.6	--
COND	92.0	80.0	89.0	78.0
K	1.19	--	1.40	--
MG	41.0	--	39.0	--
NA	23.0	--	28.0	--
PH	7.10	6.89	7.54	6.91
SO4	2.71	--	0.710	--
SR	0.220	--	0.240	--

* Field data stored with next day's date.

Table B4

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 03B

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	627.	730.	580.	690.
ALKOH	<5.00	--	<5.00	--
B	0.130	--	0.260	--
CA	157.	--	135.	--
CL	18.6	--	15.6	--
COND	114.	113.	107.	99.0
K	0.620	--	0.410	--
MG	61.0	--	54.0	--
NA	12.0	--	14.0	--
PH	7.30	6.81	7.41	6.81
SO4	46.4	--	19.5	--
SR	0.220	--	0.210	--

* Field data stored with next day's date.

Table B5

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 05A

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	360.	550.	383.	560.
ALKOH	<5.00	--	<5.00	--
B	0.0900	--	0.120	--
CA	123.	--	114.	--
CL	39.4	--	28.6	--
COND	98.0	113.	95.0	92.0
K	1.18	--	1.22	--
MG	49.0	--	45.0	--
NA	15.0	--	21.0	--
PH	6.50	6.61	6.90	6.70
SO4	175.	--	105.	--
SR	0.220	--	0.230	--

* Field data stored with next day's date.

Table B6

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 05B

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	106.	470.	128.	470.
ALKOH	<5.00	--	<5.00	--
B	0.290	--	0.210	--
CA	149.	--	166.	--
CL	7.20	--	33.9	--
COND	139.	160.	150.	158.
K	0.380	--	0.420	--
MG	74.0	--	81.0	--
NA	11.0	--	12.0	--
PH	6.20	6.38	5.82	6.53
SO4	114.	--	735.	--
SR	0.190	--	0.230	--

* Field data stored with next day's date.

Table B7

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 08A

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	370.	590.	372.	600.
ALKOH	<5.00	--	<5.00	--
B	0.120	--	0.110	--
CA	94.0	--	82.0	--
CL	10.4	--	9.26	--
COND	74.0	84.0	70.0	80.0
K	0.810	--	0.910	--
MG	41.0	--	38.0	--
NA	9.20	--	10.7	--
PH	6.60	6.66	6.76	6.67
SO4	28.4	--	0.480	--
SR	0.140	--	0.140	--

* Field data stored with next day's date.

Table B8

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 08B

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	497.	670.	452.	630.
ALKOH	<5.00	--	<5.00	--
B	0.290	--	0.310	--
CA	103.	--	94.0	--
CL	8.32	--	5.46	--
COND	85.0	90.0	84.0	81.0
K	0.980	--	0.800	--
MG	56.0	--	55.0	--
NA	13.0	--	9.54	--
PH	6.90	6.82	7.32	6.92
SO4	1.01	--	15.1	--
SR	0.290	--	0.360	--

* Field data stored with next day's date.

Table B9

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 12A

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	--	--
ALKHCO3	742.	900.	--	--
ALKOH	<5.00	--	--	--
B	0.230	--	--	--
CA	172.	--	--	--
CL	6.64	--	--	--
COND	122.	125.	--	--
K	1.60	--	--	--
MG	71.0	--	--	--
NA	14.0	--	--	--
PH	6.80	6.62	--	--
SO4	0.200	--	--	--
SR	0.380	--	--	--

* Field data stored with next day's date.

Table B10

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 12B

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	--	--
ALKHCO3	554.	680.	--	--
ALKOH	<5.00	--	--	--
B	0.280	--	--	--
CA	125.	--	--	--
CL	10.3	--	--	--
COND	97.0	95.0	--	--
K	1.19	--	--	--
MG	54.0	--	--	--
NA	13.0	--	--	--
PH	7.00	6.57	--	--
SO4	0.230	--	--	--
SR	0.250	--	--	--

* Field data stored with next day's date.

Table B11

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 15A

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	269.	580.	236.	520.
ALKOH	<5.00	--	<5.00	--
B	1.52	--	2.75	--
CA	251.	--	312.	--
CL	26.1	--	22.0	--
COND	239.	273.	285.	310.
K	4.30	--	4.60	--
MG	108.	--	118.	--
NA	110.	--	200.	--
PH	6.50	6.42	6.06	6.47
SO4	1220	--	1650	--
SR	0.500	--	0.590	--

* Field data stored with next day's date.

Table B12

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 15B

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	224.	390.	200.	430.
ALKOH	<5.00	--	<5.00	--
B	0.830	--	2.80	--
CA	108.	--	162.	--
CL	12.4	--	12.8	--
COND	105.	105.	160.	152.
K	4.00	--	3.70	--
MG	49.0	--	64.0	--
NA	43.0	--	110.	--
PH	6.60	6.56	6.73	6.47
SO4	351.	--	682.	--
SR	0.180	--	0.250	--

* Field data stored with next day's date.

Table B13

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 18A

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	350.	350.	366.	400.
ALKOH	<5.00	--	<5.00	--
B	0.640	--	1.04	--
CA	118.	--	141.	--
CL	7.75	--	8.63	--
COND	90.0	78.0	105.	90.0
K	2.30	--	0.890	--
MG	40.0	--	49.0	--
NA	15.0	--	24.0	--
PH	7.20	6.72	7.32	6.61
SO4	138.	--	240.	--
SR	0.290	--	0.430	--

* Field data stored with next day's date.

Table B14

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 18B

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	373.	370.	384.	460.
ALKOH	<5.00	--	<5.00	--
B	0.390	--	0.500	--
CA	123.	--	128.	--
CL	7.25	--	5.62	--
COND	82.0	70.0	87.0	74.0
K	3.00	--	0.410	--
MG	33.0	--	35.0	--
NA	11.0	--	13.0	--
PH	8.00	6.83	7.78	6.83
SO4	76.5	--	111.	--
SR	0.200	--	0.210	--

* Field data stored with next day's date.

Table B15

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 20A

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	503.	520.	600.	680.
ALKOH	<5.00	--	<5.00	--
B	1.55	--	4.48	--
CA	124.	--	163.	--
CL	11.5	--	23.0	--
COND	113.	95.0	163.	140.
K	4.00	--	2.84	--
MG	59.0	--	89.0	--
NA	41.0	--	88.0	--
PH	7.10	6.65	7.19	6.48
SO4	139.	--	341.	--
SR	0.190	--	0.230	--

* Field data stored with next day's date.

Table B16

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 20B

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	455.	470.	648.	700.
ALKOH	<5.00	--	<5.00	--
B	1.88	--	4.13	--
CA	120.	--	195.	--
CL	13.5	--	24.6	--
COND	107.	90.0	172.	142.
K	4.00	--	3.40	--
MG	52.0	--	84.0	--
NA	42.0	--	82.0	--
PH	7.00	6.48	7.03	6.35
SO4	141.	--	338.	--
SR	0.170	--	0.290	--

* Field data stored with next day's date.

Table B17

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 21A

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	170.	150.	144.	180.
ALKOH	<5.00	--	<5.00	--
B	0.210	--	0.180	--
CA	42.0	--	33.0	--
CL	13.7	--	9.08	--
COND	42.0	36.5	33.5	33.0
K	1.50	--	1.00	--
MG	17.0	--	16.0	--
NA	6.50	--	6.60	--
PH	7.10	6.48	7.50	6.43
SO4	10.6	--	11.6	--
SR	0.0900	--	0.0600	--

* Field data stored with next day's date.

Table B18

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 21B

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	77.4	70.0	28.0	70.0
ALKOH	<5.00	--	<5.00	--
B	0.290	--	0.520	--
CA	23.0	--	13.0	--
CL	9.05	--	5.95	--
COND	21.4	18.5	1.25	11.5
K	1.26	--	1.00	--
MG	8.50	--	5.40	--
NA	6.90	--	5.40	--
PH	6.70	5.80	6.98	5.56
SO4	14.6	--	16.7	--
SR	0.0600	--	<0.0500	--

* Field data stored with next day's date.

Table B19

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 22A

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	591.	640.	584.	670.
ALKOH	<5.00	--	<5.00	--
B	0.130	--	0.110	--
CA	131.	--	135.	--
CL	19.6	--	17.0	--
COND	108.	103.	105.	95.0
K	1.60	--	1.90	--
MG	52.0	--	52.0	--
NA	34.0	--	40.0	--
PH	6.90	6.83	7.22	6.72
SO4	31.9	--	14.6	--
SR	0.260	--	0.300	--

* Field data stored with next day's date.

Table B20

ASH CELL GROUND WATER QUALITY - TBTGS - 1987

Location: 22B

Test	Date sampled (Year-Month-Day) 870610	870611*	870924	870925*
ALKCO3	<5.00	--	<5.00	--
ALKHCO3	646.	640.	728.	760.
ALKOH	<5.00	--	<5.00	--
B	0.510	--	0.670	--
CA	133.	--	173.	--
CL	4.02	--	1.65	--
COND	109.	88.0	117.	98.0
K	1.26	--	0.830	--
MG	60.0	--	79.0	--
NA	30.0	--	30.0	--
PH	7.30	6.61	7.76	6.59
SO4	3.01	--	9.19	--
SR	0.250	--	0.310	--

* Field data stored with next day's date.

APPENDIX C

ASH CELL GROUND WATER QUALITY TBTGS - 1987

Table

C1 ASH CELL AREA GROUND WATER QUALITY TBTGS - 1987
TEST: pH

C2 ASH CELL AREA GROUND WATER QUALITY TBTGS - 1987
TEST: ALK HCO_3

C3 ASH CELL AREA GROUND WATER QUALITY TBTGS - 1987
TEST: SO_4

C4 ASH CELL AREA GROUND WATER QUALITY TBTGS - 1987
TEST: Na

C5 ASH CELL AREA GROUND WATER QUALITY TBTGS - 1987
TEST: Mg

C6 ASH CELL AREA GROUND WATER QUALITY TBTGS - 1987
TEST: B

C7 ASH CELL AREA GROUND WATER QUALITY TBTGS - 1987
TEST: Sr

Figure

2 TBTGS Ash - Selected Borehole pH (Labs) vs Time

3 TBTGS Ash - Selected Boreholes HCO_3 Alkalinity (Lab) vs Time

4 TBTGS Ash - Selected Boreholes Sulphate vs Time

5 TBTGS Ash - Selected Boreholes Sodium vs Time

6 TBTGS Ash - Selected Boreholes Magnesium vs Time

7 TBTGS Ash - Selected Boreholes Boron vs Time

8 TBTGS Ash - Selected Boreholes Strontium vs Time

Table C1

ASH CELL GROUND WATER QUALITY TBTGS - 1987

Test: PH

Sampling Date (YEAR-MONTH-DAY)

Location	870610	870611*	870924	870925*
01A	6.70	6.64	7.05	6.54
01B	7.50	6.95	7.20	6.74
03A	7.10	6.89	7.54	6.91
03B	7.30	6.81	7.41	6.81
05A	6.50	6.61	6.90	6.70
05B	6.20	6.38	5.82	6.53
08A	6.60	6.66	6.76	6.67
08B	6.90	6.82	7.32	6.92
12A	6.80	6.62	--	--
12B	7.00	6.57	--	--
15A	6.50	6.42	6.06	6.47
15B	6.60	6.56	6.73	6.47
18A	7.20	6.72	7.32	6.61
18B	8.00	6.83	7.78	6.83
20A	7.10	6.65	7.19	6.48
20B	7.00	6.48	7.03	6.35
21A	7.10	6.48	7.50	6.43
21B	6.70	5.80	6.98	5.56
22A	6.90	6.83	7.22	6.72
22B	7.30	6.61	7.76	6.59

* Field data recorded using next day's date.

Table C2

ASH CELL GROUND WATER QUALITY TBTGS - 1987

Test: ALKHCO3

Location	Sampling Date (YEAR-MONTH-DAY) 870610	870611*	870924	870925*
01A	552.	680.	555.	740.
01B	416.	420.	664.	800.
03A	495.	520.	472.	540.
03B	627.	730.	580.	690.
05A	360.	550.	383.	560.
05B	106.	470.	128.	470.
08A	370.	590.	372.	600.
08B	497.	670.	452.	630.
12A	742.	900.	--	--
12B	554.	680.	--	--
15A	269.	580.	236.	520.
15B	224.	390.	200.	430.
18A	350.	350.	366.	400.
18B	373.	370.	384.	460.
20A	503.	520.	600.	680.
20B	455.	470.	648.	700.
21A	170.	150.	144.	180.
21B	77.4	70.0	28.0	70.0
22A	591.	640.	584.	670.
22B	646.	640.	728.	760.

* Field data recorded using next day's date.

Table C3

ASH CELL GROUND WATER QUALITY TBTGS - 1987

Test: SO4

Location	Sampling Date (YEAR-MONTH-DAY) 870610	870611*	870924	870925*
01A	118.	--	244.	--
01B	19.7	--	207.	--
03A	2.71	--	0.710	--
03B	46.4	--	19.5	--
05A	175.	--	105.	--
05B	114.	--	735.	--
08A	28.4	--	0.480	--
08B	1.01	--	15.1	--
12A	0.200	--	--	--
12B	0.230	--	--	--
15A	1220	--	1650	--
15B	351.	--	682.	--
18A	138.	--	240.	--
18B	76.5	--	111.	--
20A	139.	--	341.	--
20B	141.	--	338.	--
21A	10.6	--	11.6	--
21B	14.6	--	16.7	--
22A	31.9	--	14.6	--
22B	3.01	--	9.19	--

* Field data recorded using next day's date.

Table C4

ASH CELL GROUND WATER QUALITY TBTGS - 1987

Test: NA

	Sampling Date (YEAR-MONTH-DAY)			
Location	870610	870611*	870924	870925*
01A	17.0	--	26.0	--
01B	21.0	--	34.0	--
03A	23.0	--	28.0	--
03B	12.0	--	14.0	--
05A	15.0	--	21.0	--
05B	11.0	--	12.0	--
08A	9.20	--	10.7	--
08B	13.0	--	9.54	--
12A	14.0	--	--	--
12B	13.0	--	--	--
15A	110.	--	200.	--
15B	43.0	--	110.	--
18A	15.0	--	24.0	--
18B	11.0	--	13.0	--
20A	41.0	--	88.0	--
20B	42.0	--	82.0	--
21A	6.50	--	6.60	--
21B	6.90	--	5.40	--
22A	34.0	--	40.0	--
22B	30.0	--	30.0	--

* Field data recorded using next day's date.

Table C5

ASH CELL GROUND WATER QUALITY TBTGS - 1987

Test: MG

Location	Sampling Date (YEAR-MONTH-DAY) 870610	870611*	870924	870925*
01A	69.0	--	79.0	--
01B	44.0	--	94.0	--
03A	41.0	--	39.0	--
03B	61.0	--	54.0	--
05A	49.0	--	45.0	--
05B	74.0	--	81.0	--
08A	41.0	--	38.0	--
08B	56.0	--	55.0	--
12A	71.0	--	--	--
12B	54.0	--	--	--
15A	108.	--	118.	--
15B	49.0	--	64.0	--
18A	40.0	--	49.0	--
18B	33.0	--	35.0	--
20A	59.0	--	89.0	--
20B	52.0	--	84.0	--
21A	17.0	--	16.0	--
21B	8.50	--	5.40	--
22A	52.0	--	52.0	--
22B	60.0	--	79.0	--

* Field data recorded using next day's date.

Table C6

ASH CELL GROUND WATER QUALITY TBTGS - 1987

Test: B

Location	Sampling Date (YEAR-MONTH-DAY) 870610	870611*	870924	870925*
01A	0.290	--	1.01	--
01B	0.780	--	2.01	--
03A	0.0900	--	0.100	--
03B	0.130	--	0.260	--
05A	0.0900	--	0.120	--
05B	0.290	--	0.210	--
08A	0.120	--	0.110	--
08B	0.290	--	0.310	--
12A	0.230	--	--	--
12B	0.280	--	--	--
15A	1.52	--	2.75	--
15B	0.830	--	2.80	--
18A	0.640	--	1.04	--
18B	0.390	--	0.500	--
20A	1.55	--	4.48	--
20B	1.88	--	4.13	--
21A	0.210	--	0.180	--
21B	0.290	--	0.520	--
22A	0.130	--	0.110	--
22B	0.510	--	0.670	--

* Field data recorded using next day's date.

Table C7

ASH CELL GROUND WATER QUALITY TBTGS - 1987

Test: SR

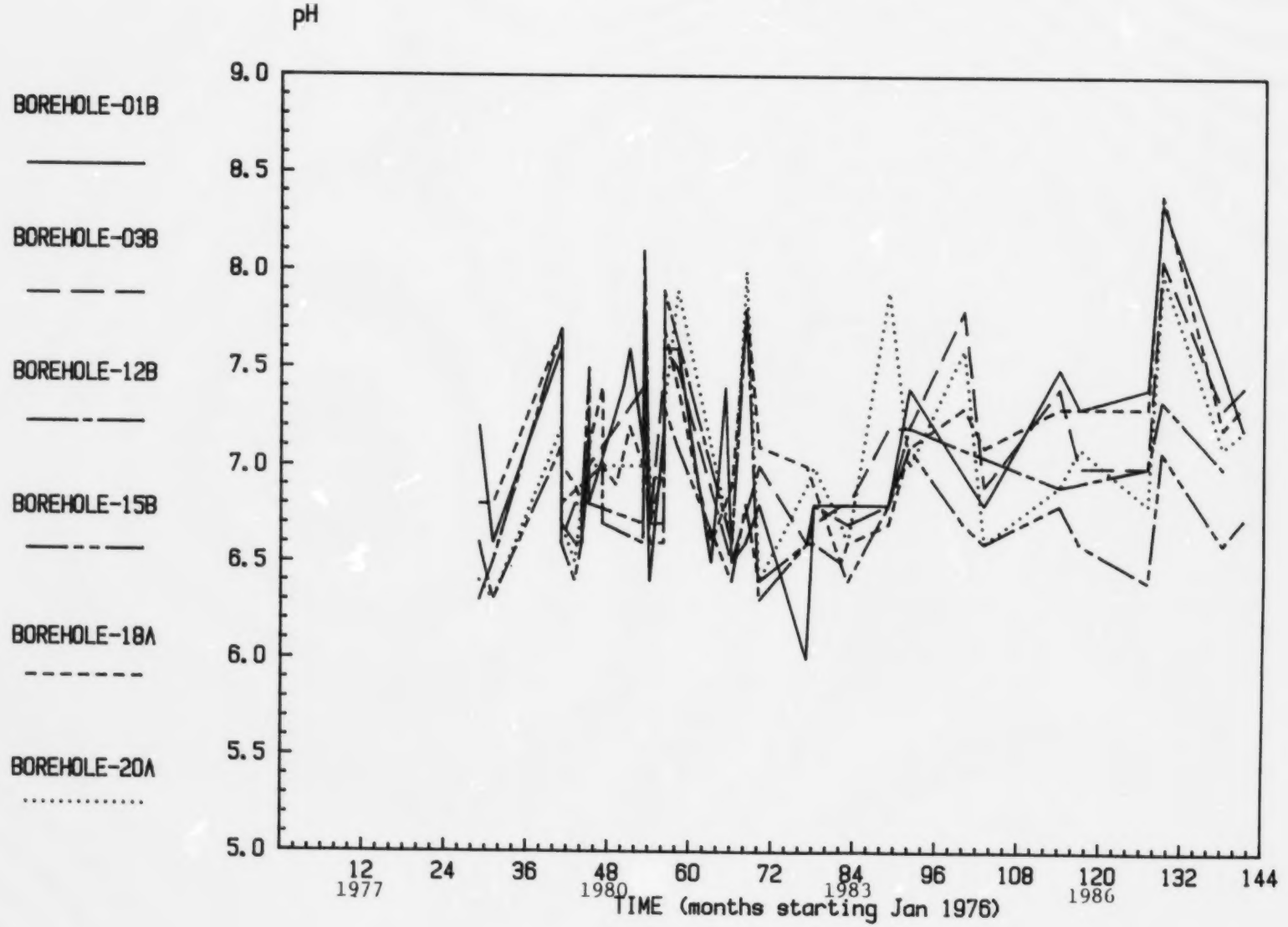
Sampling Date (YEAR-MONTH-DAY)

Location	870610	870611*	870924	870925*
01A	0.270	--	0.350	--
01B	0.190	--	0.320	--
03A	0.220	--	0.240	--
03B	0.220	--	0.210	--
05A	0.220	--	0.230	--
05B	0.190	--	0.230	--
08A	0.140	--	0.140	--
08B	0.290	--	0.360	--
12A	0.380	--	--	--
12B	0.250	--	--	--
15A	0.500	--	0.590	--
15B	0.180	--	0.250	--
18A	0.290	--	0.430	--
18B	0.200	--	0.210	--
20A	0.190	--	0.230	--
20B	0.170	--	0.290	--
21A	0.0900	--	0.0600	--
21B	0.0600	--	<0.0500	--
22A	0.260	--	0.300	--
22B	0.250	--	0.310	--

* Field data recorded using next day's date.

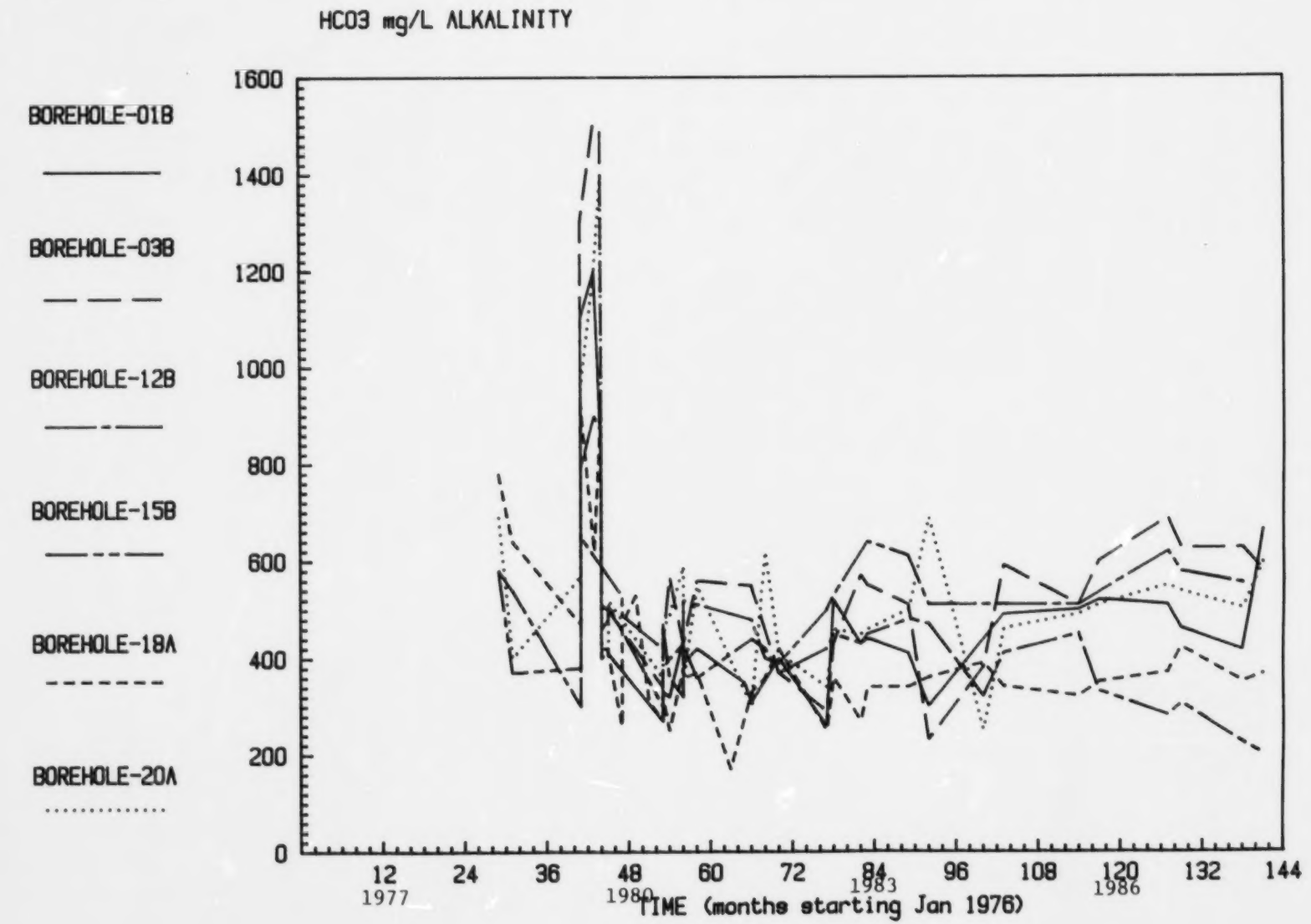
TBTGS ASH - SELECTED BOREHOLES

pH (Lab) vs TIME



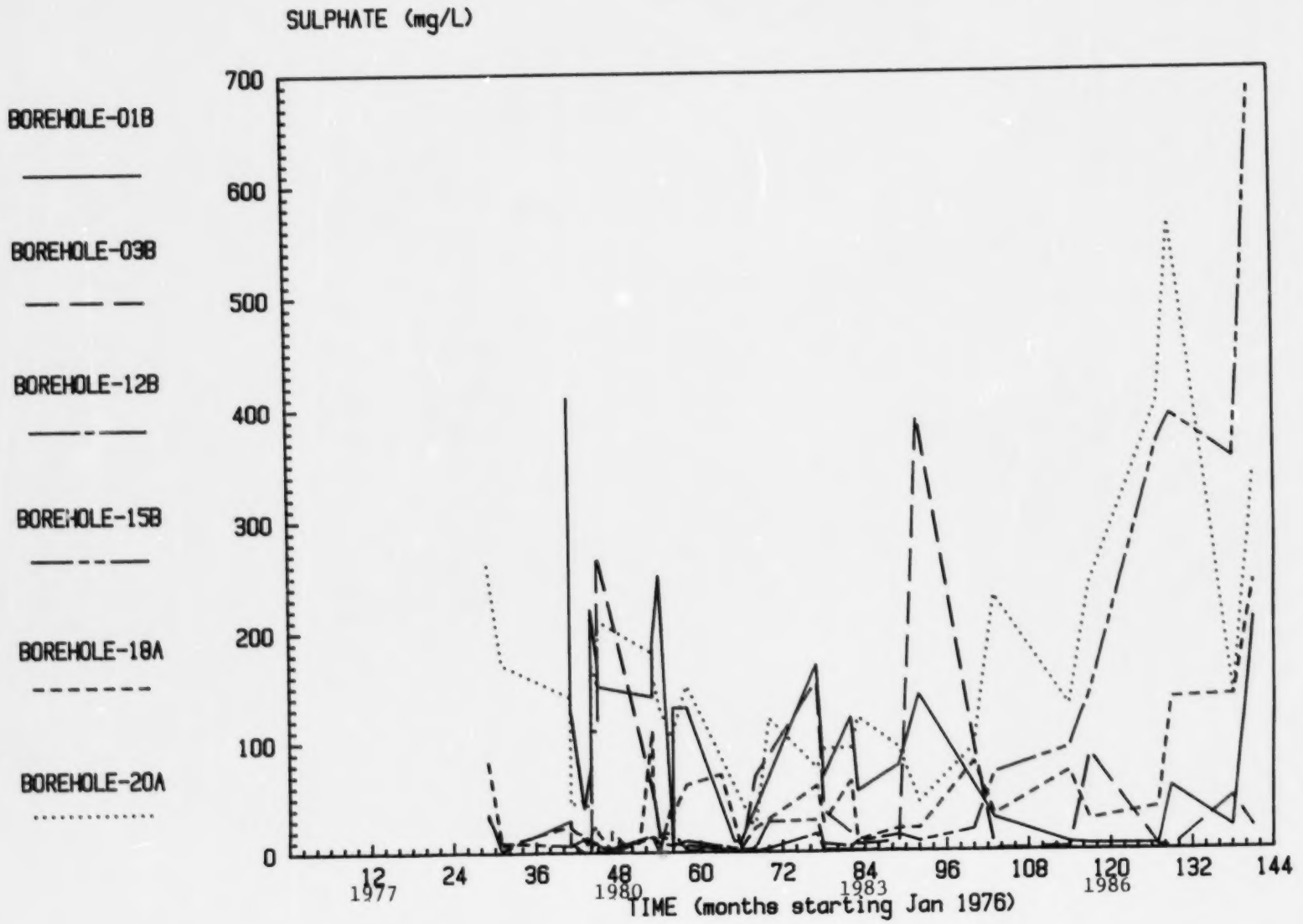
TBTGS ASH - SELECTED BOREHOLES

HCO3 ALKALINITY (LAB) vs TIME



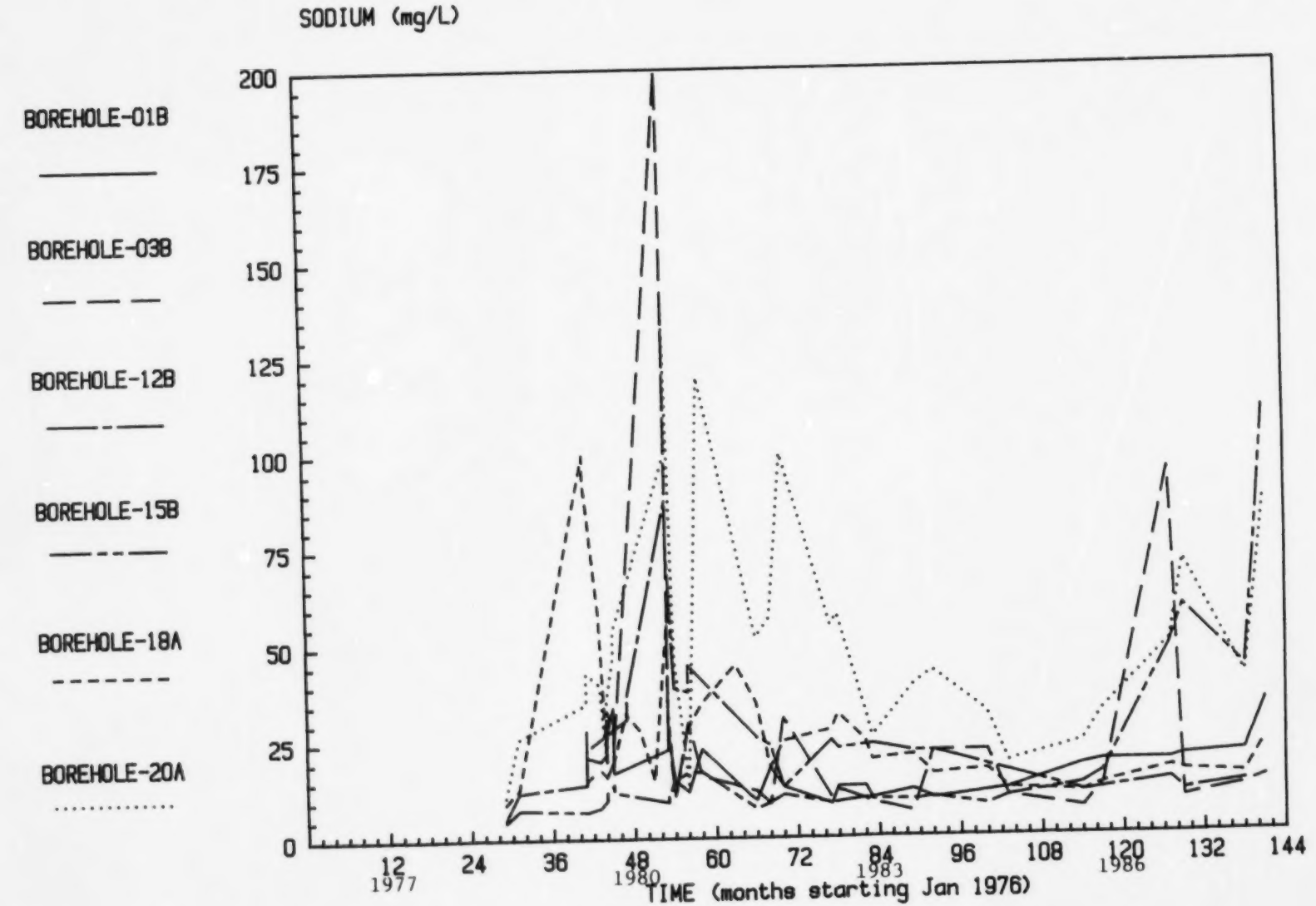
TBTGS ASH - SELECTED BOREHOLES

SULPHATE vs TIME



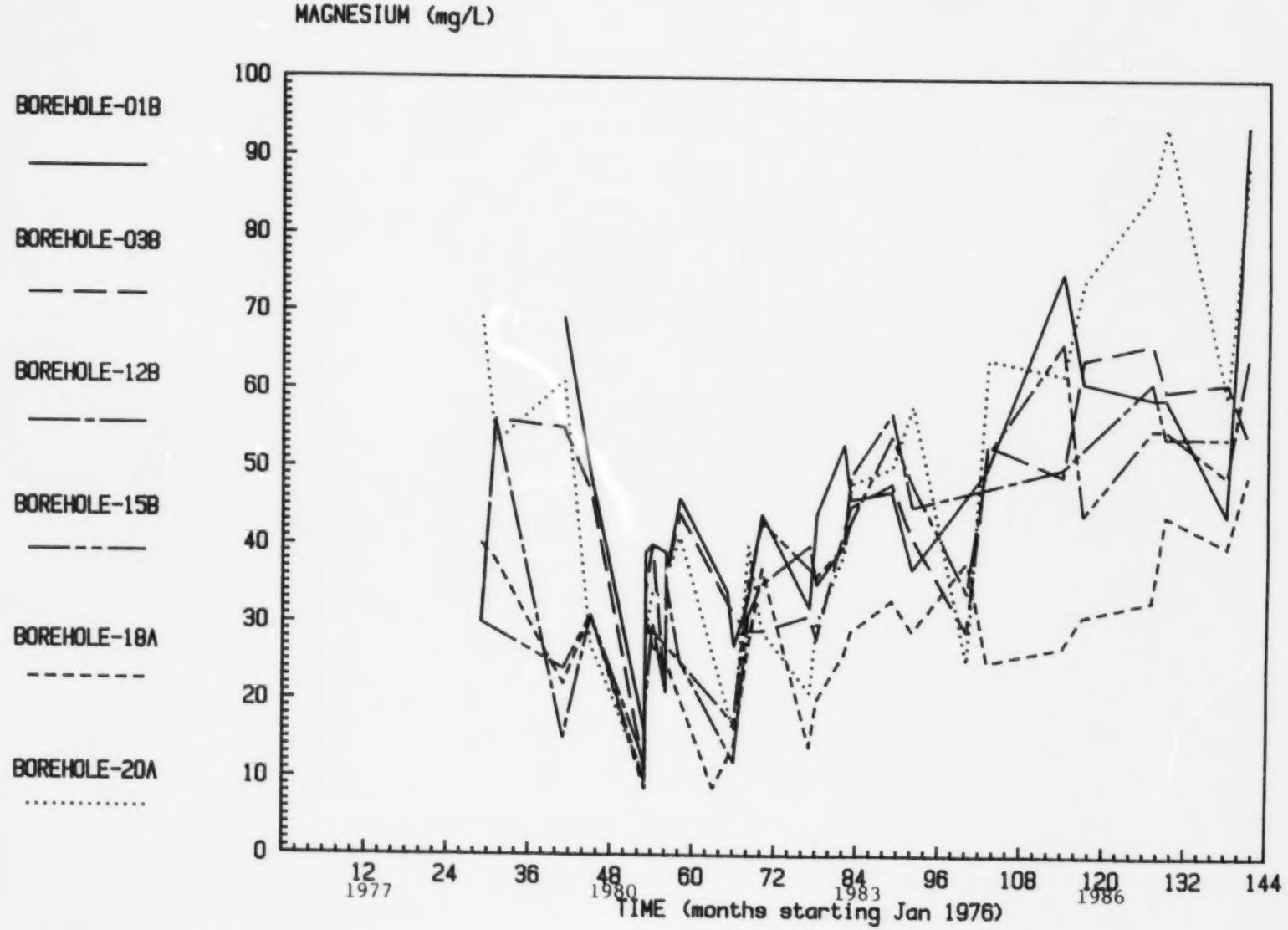
TBTGS ASH - SELECTED BOREHOLES

SODIUM vs TIME



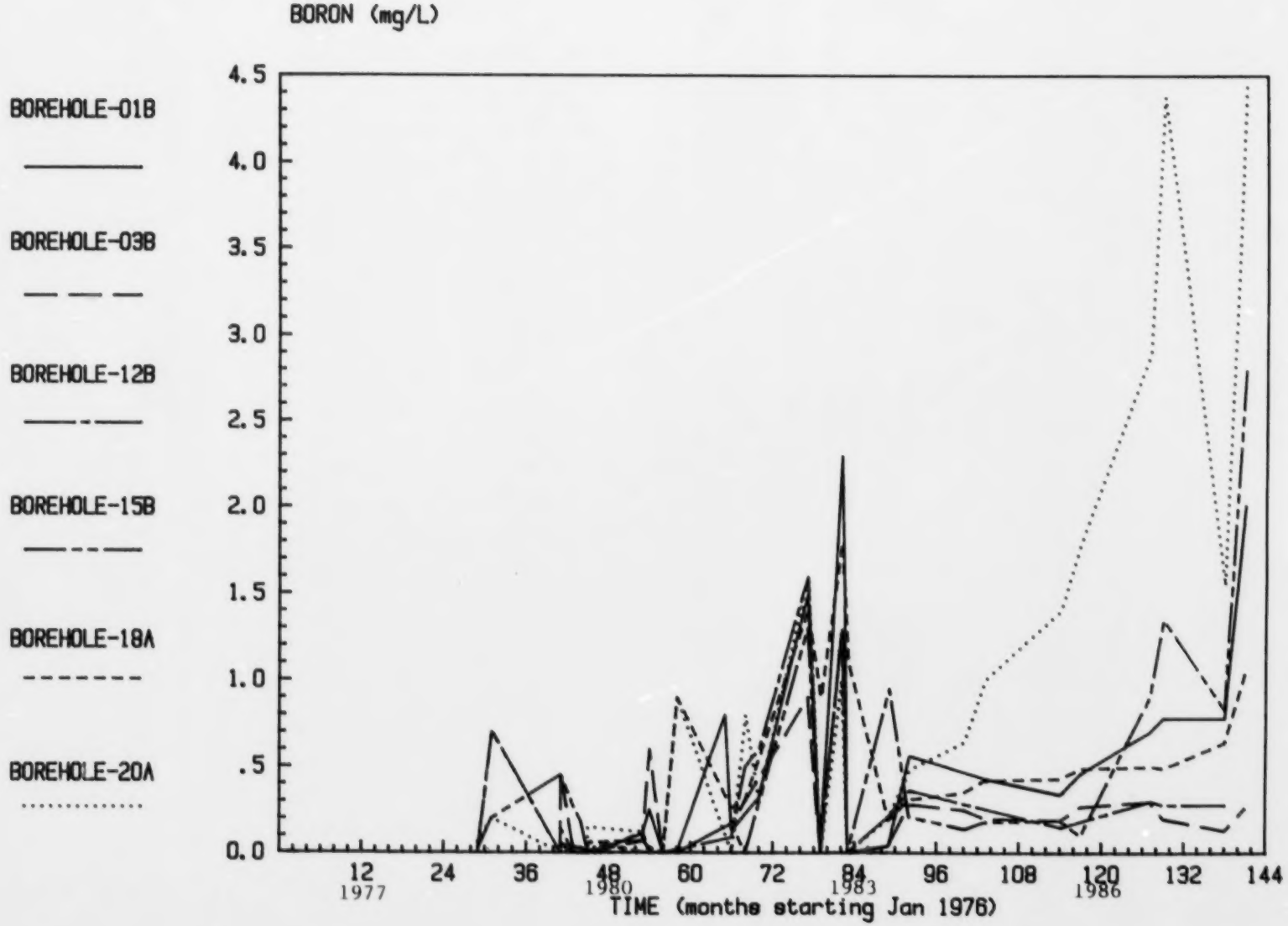
TBTGS ASH - SELECTED BOREHOLES

MAGNESIUM vs TIME



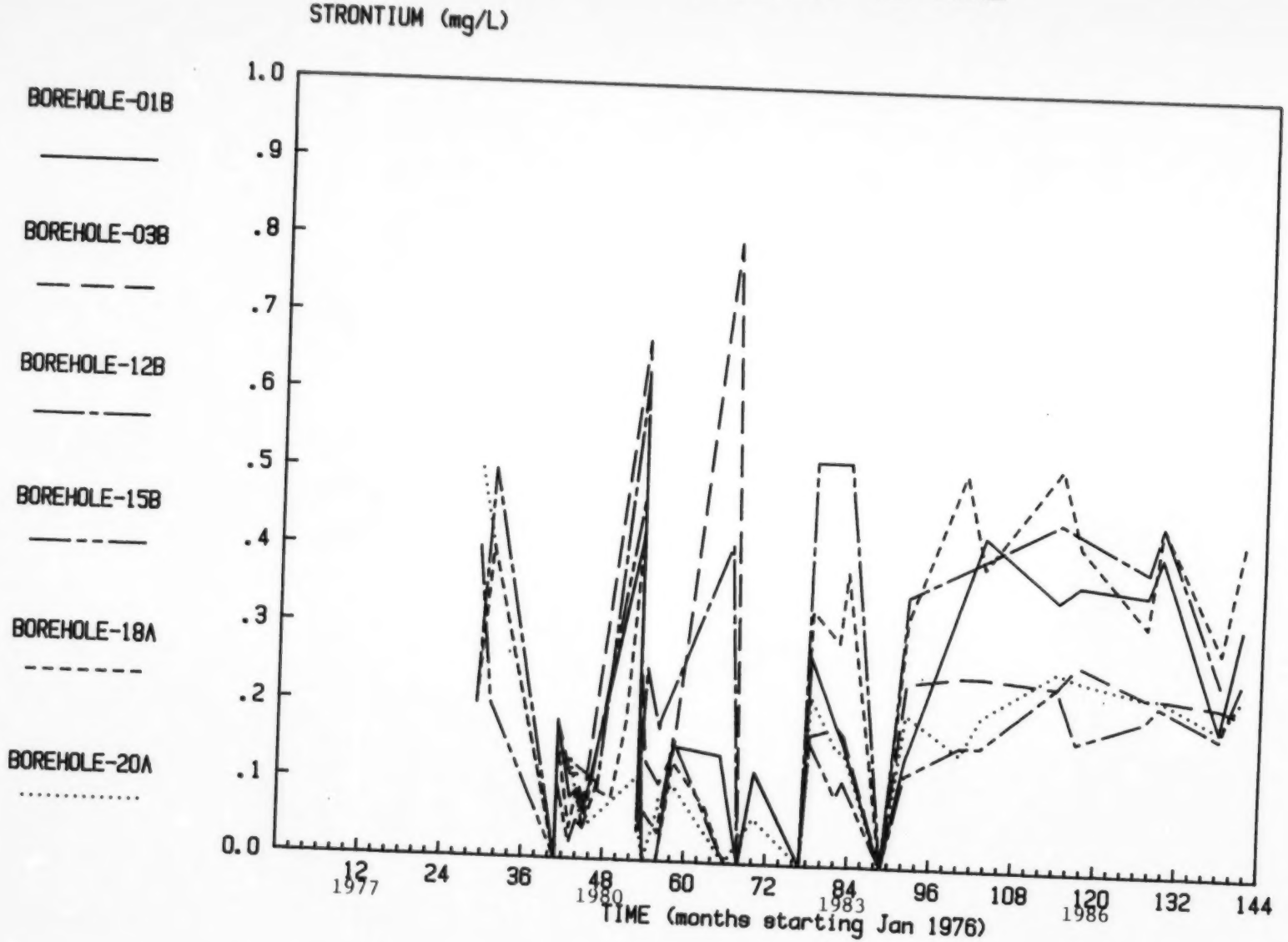
TBTGS ASH - SELECTED BOREHOLES

BORON vs TIME



TBTGS ASH - SELECTED BOREHOLES

STRONTIUM vs TIME



APPENDIX D

ASH CELL GROUND WATER QUALITY - 1987 THUNDER BAY TGS EXTENSION

MAJOR ION BALANCES

Table D1 - Sample Date 87-06-10
Table D2 - Sample Date 87-09-24

PIPER PLOTS

Figure 9 - Sample Date 87-06-10
Figure 10 - Sample Date 87-09-24

Table D1

Major Ion Chemistry
Ash Disposal Area Ground Water Chemistry - TBTGS - 1987
Date: 870610

Cations

Location	Number	Calcium			Magnesium			Sodium			Potassium			Total Ions (EPM)	
		mg/L	EPM	%EPM	mg/L	EPM	%EPM	mg/L	EPM	%EPM	mg/L	EPM	%EPM	Cation	Anion
01A	1	161.00	8.03	55.41	69.00	5.68	39.16	17.00	0.74	5.10	1.84	0.05	0.32	14.50	15.28
01B	2	89.00	4.44	49.04	44.00	3.62	39.98	21.00	0.91	10.09	3.14	0.08	0.89	9.06	9.51
03A	3	113.00	5.64	56.14	41.00	3.37	33.59	23.00	1.00	9.96	1.19	0.03	0.30	10.04	10.53
03B	4	157.00	7.83	58.50	61.00	5.02	37.48	12.00	0.52	3.90	0.62	0.02	0.12	13.39	14.03
05A	5	123.00	6.14	56.56	49.00	4.03	37.15	15.00	0.65	6.01	1.18	0.03	0.28	10.85	11.95
05B	6	149.00	7.44	53.06	74.00	6.09	43.46	11.00	0.48	3.41	0.38	0.01	0.07	14.01	4.70 *
08A	7	94.00	4.69	55.28	41.00	3.37	39.76	9.20	0.40	4.72	0.81	0.02	0.24	8.49	8.28
08B	8	103.00	5.14	49.72	56.00	4.61	44.57	13.00	0.57	5.47	0.98	0.03	0.24	10.34	10.19
12A	9	172.00	8.58	56.93	71.00	5.84	38.76	14.00	0.61	4.04	1.60	0.04	0.27	15.08	15.03
12B	10	125.00	6.24	55.31	54.00	4.44	39.40	13.00	0.57	5.01	1.19	0.03	0.27	11.28	11.37
15A	11	251.00	12.52	47.61	108.00	8.89	33.78	110.00	4.78	18.19	4.30	0.11	0.42	26.31	31.51
15B	12	108.00	5.39	47.30	49.00	4.03	35.39	43.00	1.87	16.42	4.00	0.10	0.90	11.39	12.14
18A	13	118.00	5.89	59.53	40.00	3.29	33.28	15.00	0.65	6.60	2.30	0.06	0.59	9.89	10.09
18B	14	123.00	6.14	65.24	33.00	2.72	28.86	11.00	0.48	5.09	3.00	0.08	0.82	9.41	9.25
20A	15	124.00	6.19	47.86	59.00	4.85	37.55	41.00	1.78	13.79	4.00	0.10	0.79	12.93	13.27
20B	16	120.00	5.99	49.10	52.00	4.28	35.08	42.00	1.83	14.98	4.00	0.10	0.84	12.20	12.41
21A	17	42.00	2.10	54.92	17.00	1.40	36.66	6.50	0.28	7.41	1.50	0.04	1.01	3.82	4.01
21B	18	23.00	1.15	52.66	8.50	0.70	32.09	6.90	0.30	13.77	1.26	0.03	1.48	2.18	2.11
22A	19	131.00	6.54	52.99	52.00	4.28	34.69	34.00	1.48	11.99	1.60	0.04	0.33	12.34	13.03
22B	20	133.00	6.64	51.40	60.00	4.94	38.24	30.00	1.30	10.11	1.26	0.03	0.25	12.91	13.09

* Indicates that cations and anions do not lie within 10% of mean

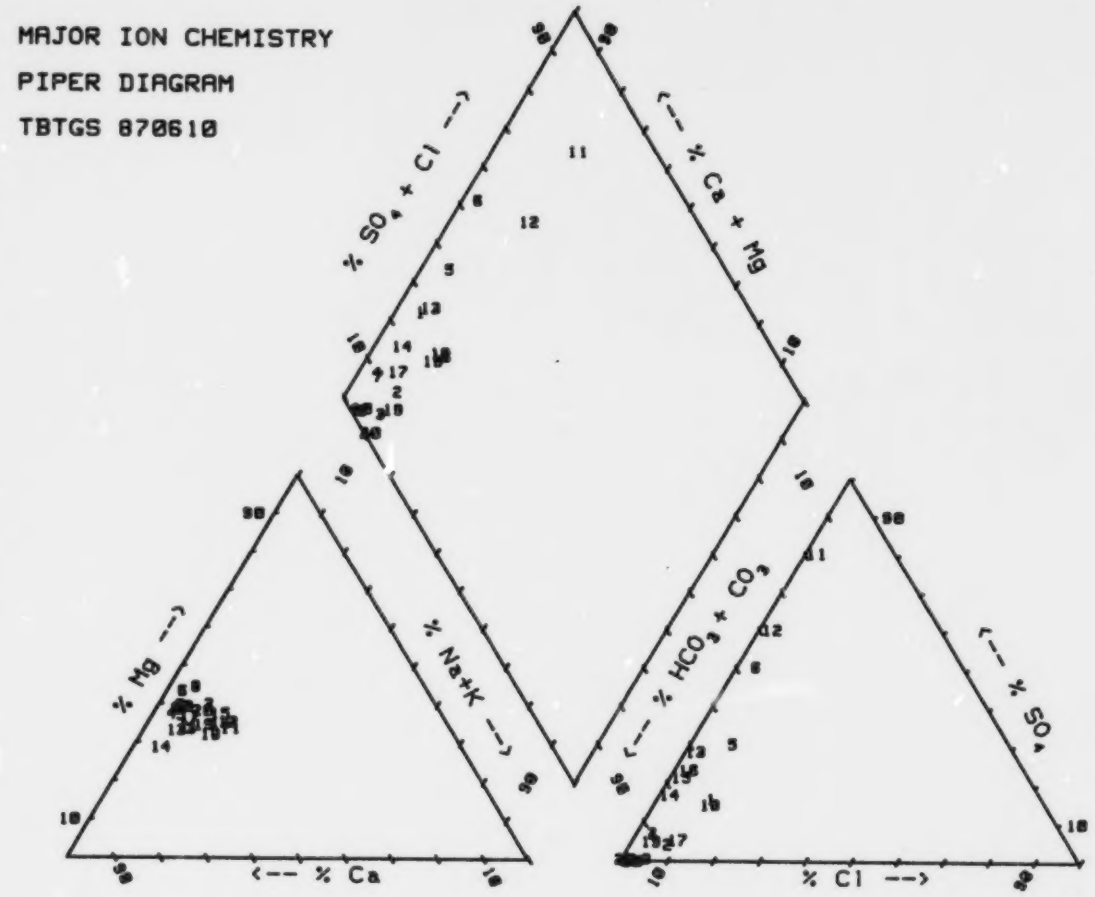
Table D1 (cont'd)

Major Ion Chemistry
Ash Disposal Area Ground Water Chemistry - TBTGS - 1987
Date: 870610

Anions

Location	Number	Chloride			Sulphate			Bicarbonate as CaCO3			Carbonate as CaCO3			Total Ions (EPM)		
		mg/L	EPM	%EPM	mg/L	EPM	%EPM	mg/L	EPM	%EPM	mg/L	EPM	%EPM	Anion	Cation	
01A	1	63.50	1.79	11.72	118.00	2.46	16.07	552.00	11.04	72.21	<5.00	0.00	0.00	15.28	14.50	
01B	2	27.80	0.78	8.24	19.70	0.41	4.31	416.00	8.32	87.44	<5.00	0.00	0.00	9.51	9.06	
03A	3	20.60	0.58	5.52	2.71	0.06	0.54	495.00	9.90	93.95	<5.00	0.00	0.00	10.53	10.04	
03B	4	18.60	0.52	3.74	46.40	0.97	6.89	627.00	12.53	89.37	<5.00	0.00	0.00	14.03	13.39	
05A	5	39.40	1.11	9.30	175.00	3.64	30.48	360.00	7.20	60.22	<5.00	0.00	0.00	11.95	10.85	
05B	6	7.20	0.20	4.32	114.00	2.37	50.55	106.00	2.12	45.13	<5.00	0.00	0.00	4.70	14.01	*
08A	7	10.40	0.29	3.54	28.40	0.59	7.14	370.00	7.40	89.32	<5.00	0.00	0.00	8.28	8.49	
08B	8	8.32	0.23	2.30	1.01	0.02	0.21	497.00	9.94	97.49	<5.00	0.00	0.00	10.19	10.34	
12A	9	6.64	0.19	1.25	0.20	0.00	0.03	742.00	14.83	98.73	<5.00	0.00	0.00	15.03	15.08	
12B	10	10.30	0.29	2.55	0.23	0.00	0.04	554.00	11.08	97.40	<5.00	0.00	0.00	11.37	11.28	
15A	11	26.10	0.74	2.34	1220.00	25.40	80.60	269.00	5.38	17.06	<5.00	0.00	0.00	31.51	26.31	
15B	12	12.40	0.35	2.88	351.00	7.31	60.22	224.00	4.48	36.90	<5.00	0.00	0.00	12.14	11.39	
18A	13	7.75	0.22	2.17	138.00	2.87	28.48	350.00	7.00	69.35	<5.00	0.00	0.00	10.09	9.89	
18B	14	7.25	0.20	2.21	76.50	1.59	17.21	373.00	7.46	80.58	<5.00	0.00	0.00	9.25	9.41	
20A	15	11.50	0.32	2.44	139.00	2.89	21.80	503.00	10.06	75.75	<5.00	0.00	0.00	13.27	12.93	
20B	16	13.50	0.38	3.07	141.00	2.94	23.65	455.00	9.10	73.28	<5.00	0.00	0.00	12.41	12.20	
21A	17	13.70	0.39	9.65	10.60	0.22	5.51	170.00	3.40	84.84	<5.00	0.00	0.00	4.01	3.82	
21B	18	9.05	0.26	12.12	14.60	0.30	14.43	77.40	1.55	73.45	<5.00	0.00	0.00	2.11	2.18	
22A	19	19.60	0.55	4.24	31.90	0.66	5.10	591.00	11.82	90.66	<5.00	0.00	0.00	13.03	12.34	
22B	20	4.02	0.11	0.87	3.01	0.06	0.48	646.00	12.91	98.66	<5.00	0.00	0.00	13.09	12.91	

* Indicates that cations and anions do not lie within 10% of mean



Piper Number	Corresponding Piezometer Location
1	1A
2	1B
3	3A
4	3B
5	5A
6	5B
7	8A
8	8B
9	12A
10	12B
11	15A
12	15B
13	18A
14	18B
15	20A
16	20B
17	21A
18	21B
19	22A
20	22B

FIGURE 9

Table D2

Major Ion Chemistry
Ash Disposal Area Ground Water Chemistry - TBTGS - 1987
Date: 870924

Cations

Location	Number	Calcium			Magnesium			Sodium			Potassium			Total Ions (EPM)	
		mg/L	EPM	%EPM	mg/L	EPM	%EPM	mg/L	EPM	%EPM	mg/L	EPM	%EPM	Cation	Anion
01A	1	190.00	9.48	55.24	79.00	6.50	37.87	26.00	1.13	6.59	2.00	0.05	0.30	17.16	17.44
01B	2	180.00	8.98	49.22	94.00	7.74	42.39	34.00	1.48	8.10	2.00	0.05	0.28	18.25	19.00
03A	3	109.00	5.44	54.93	39.00	3.21	32.41	28.00	1.22	12.30	1.40	0.04	0.36	9.90	10.14
03B	4	135.00	6.74	57.09	54.00	4.44	37.66	14.00	0.61	5.16	0.41	0.01	0.09	11.80	12.44
05A	5	114.00	5.69	55.04	45.00	3.70	35.82	21.00	0.91	8.84	1.22	0.03	0.30	10.34	10.65
05B	6	166.00	8.28	53.51	81.00	6.67	43.05	12.00	0.52	3.37	0.42	0.01	0.07	15.48	18.82
08A	7	82.00	4.09	53.09	38.00	3.13	40.57	10.70	0.47	6.04	0.91	0.02	0.30	7.71	7.71
08B	8	94.00	4.69	48.60	55.00	4.53	46.89	9.54	0.41	4.30	0.80	0.02	0.21	9.65	9.50
15A	9	312.00	15.57	45.66	118.00	9.71	28.48	200.00	8.70	25.51	4.60	0.12	0.35	34.10	39.69
15B	10	162.00	8.08	44.34	64.00	5.27	28.89	110.00	4.78	26.25	3.70	0.09	0.52	18.23	18.56
18A	11	141.00	7.04	57.98	49.00	4.03	33.23	24.00	1.04	8.60	0.89	0.02	0.19	12.13	12.56
18B	12	128.00	6.39	64.89	35.00	2.88	29.26	13.00	0.57	5.74	0.41	0.01	0.11	9.84	10.15
20A	13	163.00	8.13	42.02	89.00	7.32	37.83	88.00	3.83	19.77	2.84	0.07	0.38	19.36	19.74
20B	14	195.00	9.73	47.94	84.00	6.91	34.06	82.00	3.57	17.57	3.40	0.09	0.43	20.30	20.69
21A	15	33.00	1.65	50.27	16.00	1.32	40.19	6.60	0.29	8.76	1.00	0.03	0.78	3.28	3.38
21B	16	13.00	0.65	47.93	5.40	0.44	32.83	5.40	0.23	17.35	1.00	0.03	1.89	1.35	1.08 *
22A	17	135.00	6.74	52.61	52.00	4.28	33.42	40.00	1.74	13.59	1.90	0.05	0.38	12.80	12.46
22B	18	173.00	8.63	52.45	79.00	6.50	39.49	30.00	1.30	7.93	0.83	0.02	0.13	16.46	14.79

* Indicates that cations and anions do not lie within 10% of mean

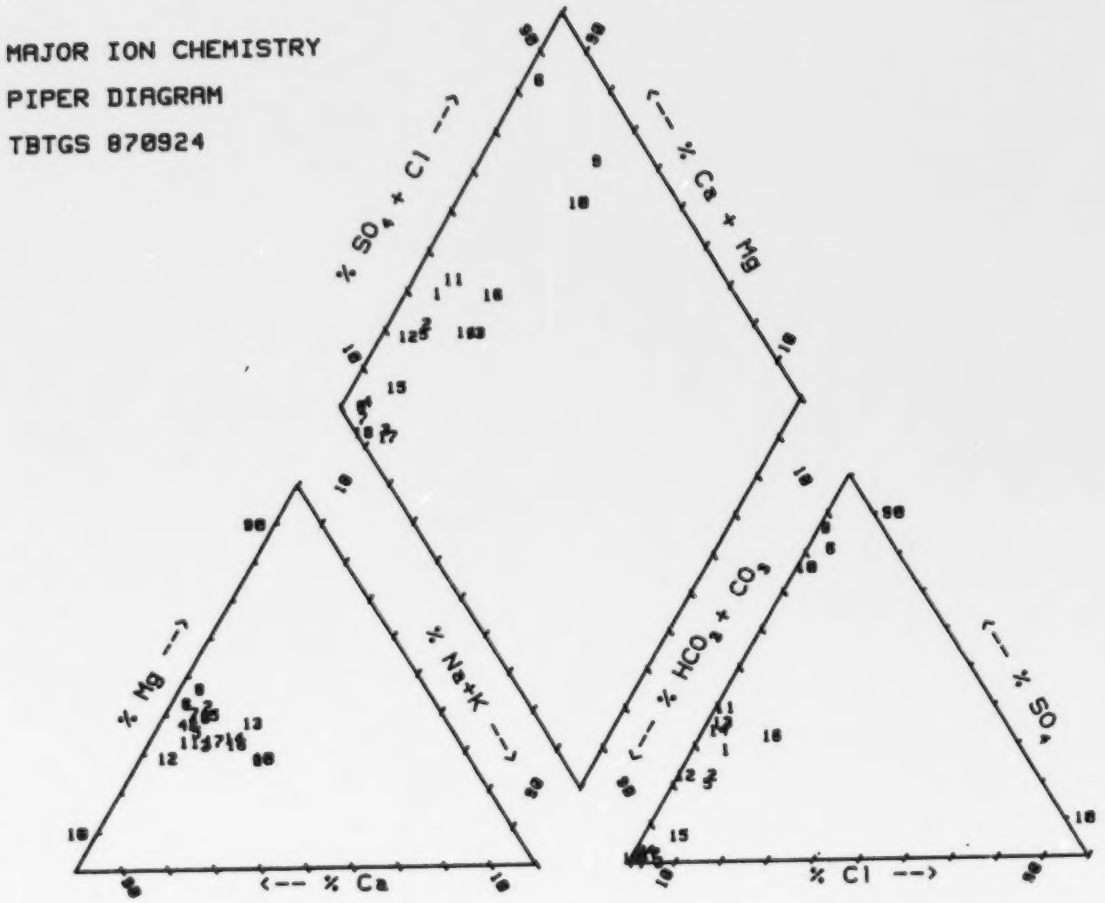
Table D2 (cont'd)

Major Ion Chemistry
Ash Disposal Area Ground Water Chemistry - TBTGS - 1987
Date: 870924

Anions

Location	Number	Chloride			Sulphate			Bicarbonate as CaCO3			Carbonate as CaCO3			Total Ions (EPM)	
		mg/L	EPM	%EPM	mg/L	EPM	%EPM	mg/L	EPM	%EPM	mg/L	EPM	%EPM	Anion	Cation
01A	1	44.80	1.26	7.25	244.00	5.08	29.13	555.00	11.10	63.62	<5.00	0.00	0.00	17.44	17.16
01B	2	50.20	1.42	7.45	207.00	4.31	22.68	664.00	13.27	69.87	<5.00	0.00	0.00	19.00	18.25
03A	3	24.60	0.69	6.84	0.71	0.01	0.15	472.00	9.44	93.01	<5.00	0.00	0.00	10.14	9.90
03B	4	15.60	0.44	3.54	19.50	0.41	3.26	580.00	11.60	93.20	<5.00	0.00	0.00	12.44	11.80
05A	5	28.60	0.81	7.57	105.00	2.19	20.53	383.00	7.66	71.90	<5.00	0.00	0.00	10.65	10.34
05B	6	33.90	0.96	5.08	735.00	15.30	81.32	128.00	2.56	13.60	<5.00	0.00	0.00	18.82	15.48
08A	7	9.26	0.26	3.39	0.48	0.01	0.13	372.00	7.44	96.48	<5.00	0.00	0.00	7.71	7.71
08B	8	5.46	0.15	1.62	15.10	0.31	3.31	452.00	9.04	95.07	<5.00	0.00	0.00	9.50	9.65
15A	9	22.00	0.62	1.56	1650.00	34.35	86.55	236.00	4.72	11.89	<5.00	0.00	0.00	39.69	34.10
15B	10	12.80	0.36	1.95	682.00	14.20	76.51	200.00	4.00	21.54	<5.00	0.00	0.00	18.56	18.23
18A	11	8.63	0.24	1.94	240.00	5.00	39.79	366.00	7.32	58.27	<5.00	0.00	0.00	12.56	12.13
18B	12	5.62	0.16	1.56	111.00	2.31	22.78	384.00	7.68	75.66	<5.00	0.00	0.00	10.15	9.84
20A	13	23.00	0.65	3.29	341.00	7.10	35.96	600.00	12.00	60.75	<5.00	0.00	0.00	19.74	19.36
20B	14	24.60	0.69	3.35	338.00	7.04	34.02	648.00	12.95	62.63	<5.00	0.00	0.00	20.69	20.30
21A	15	9.08	0.26	7.59	11.60	0.24	7.15	144.00	2.88	85.26	<5.00	0.00	0.00	3.38	3.28
21B	16	5.95	0.17	15.61	16.70	0.35	32.34	28.00	0.56	52.06	<5.00	0.00	0.00	1.08	1.35 *
22A	17	17.00	0.48	3.85	14.60	0.30	2.44	584.00	11.68	93.71	<5.00	0.00	0.00	12.46	12.80
22B	18	1.65	0.05	0.31	9.19	0.19	1.29	728.00	14.55	98.39	<5.00	0.00	0.00	14.79	16.46

* Indicates that cations and anions do not lie within 10% of mean



Piper Number	Corresponding Piezometer Location
1	1A
2	1B
3	3A
4	3B
5	5A
6	5B
7	8A
8	8B
9	15A
10	15B
11	18A
12	18B
13	20A
14	20B
15	21A
16	21B
17	22A
18	22B

FIGURE 10